Phys 347 Week 1 Lecture:

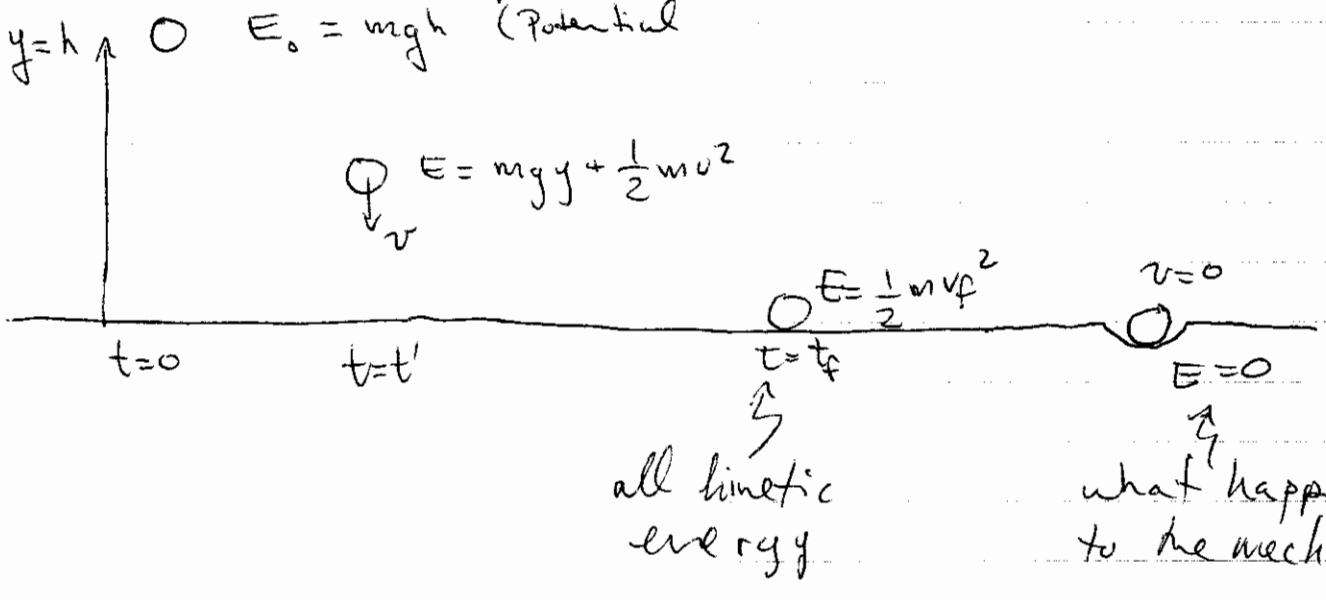
- All things in the universe are tending towards disorder, so how does order emmerge?
- To understand how order can be created we need to know about the various forms of energy that are @ work in physical systems.

Types of energy:

Potential energy: energy associated with an objects position – e.g. gravitational, spring, electrical

Kinetic energy: energy associated with motion
$E_k = \frac{1}{2}mv^2$

Consider a falling rock into some mud.



P347 - week 1

- The rock had potential energy, converted it to kinetic energy, and then hit the mud.
- At the end it has no mechanical energy, so what happened? and has energy conservation been violated?
- Ans: NO. Energy was converted into HEAT.

HEAT is a form of energy

- Total energy = heat + mechanical energy

(1) Total energy is conserved in all processes.

Q: Why doesn't the rock spontaneously return to where it started? Energy would still be conserved.

Ans: Something else has changed – the system has got more disorded (ie. mud moved, heat warmed up the air, etc)

Idea: Some energy is more useful at doing work than others.

P347 - week 1

- Heat ≡ random motion of atoms.
- It is more difficult to extract useful work out of randomly moving objects than it is from objects which are moving in a coordinated way, like a falling rock.
- Low quality energy — random, disordered motion
- high quality energy — organized motion
- How to measure disorder?

Entropy ≡ S ≡ amount of disorder in system

Useful energy ≡ Free energy = $F = E - TS$

(entropy; temperature; kinetic + potential)

- A system will change its state if it lowers the free energy. If F is minimum then the system will not change.
- 2 ways to change/lower F:
  1. lower the energy - e.g. make stronger bonds
  2. increase the disorder/entropy, S.

P347 – week 1

The Puzzle of the 2nd Law:

- Why doesn't the rock return to previous height? Why doesn't a mixture return to its unmixed state?

Ans: 2nd Law of thermodynamics:

$\Delta S \geq 0$ for isolated systems.

Not true for open systems, where $\Delta S < 0$, or the system becomes more ordered.

e.g. wate vapore in a jar will condense & become liquid ⇒ more order. So $\Delta S_{H_2O} < 0$. But heat was given off to the jar & environment, so $\Delta S_{env} > 0$. And $\Delta S_{tot} = \Delta S_{H_2O} + \Delta S_{env} \geq 0$ so that the 2nd Law is not violated.

- So biology can generate order & decrease the entropy of subsystems, but in doing so, heat is released which increases the disorder elsewhere.

- Flow of energy information: